MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

ENT4086 – DIAGNOSTIC TECHNOLOGY

(NE)

13 FEBRUARY 2023
09:00 a.m. - 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. 1. This Question paper consists of 5 pages with **4 Questions** only.
2. Attempt **ALL FOUR** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.
4. Please refer to page 5 for the Appendix on IR absorptions table.

QUESTION 1

(a) (i) With the aid of a suitable diagram, describe the working principles of transmission electron microscopy (TEM). [4+5 marks]

(ii) Discuss the strengths of TEM over the scanning electron microscopy (SEM). [4 marks]

(b) (i) With the aid of a suitable energy-level diagram, describe the electronic transitions in the cases of X-ray photoelectron emission, X-ray fluorescence, and Auger electron emission. [3+5 marks]

(ii) With the aid of the plot of X-ray fluorescent and Auger emission yields as a function of atomic number of elements, discuss the competitive processes between X-ray fluorescent and Auger process. [2+2 marks]

QUESTION 2

(a) (i) Discuss the approaches that could be adopted to improve the image contrast for measuring a low-contrast sample in scanning electron microscopy (SEM) imaging. [4 marks]

(ii) Discuss the sample preparation processes which to be carried out for measuring nanopowders and thin film samples, respectively, in transmission electron microscopy (TEM) imaging. [6 marks]

(iii) Discuss the basic sample preparation requirements and procedures which are to be taken for measuring nanoparticles in atomic force microscopy (AFM) imaging. [6 marks]

(b) **Figure Q2(b)** shows the graph of relative yield of helium (He) ions backscattered from various elements at an incident ion energy of 2 MeV as a function of the ions kinetic energy. Based on the graph, discuss the *sensitivity* and *mass resolution* of Rutherford backscattering spectroscopy (RBS) in detections of light and heavy elements.

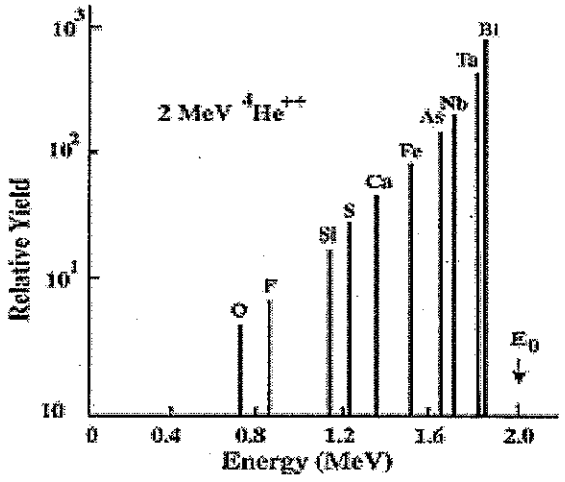

Figure Q2(b)

[9 marks]

Continued...

QUESTION 3

(a) **Figure Q3(a)** shows the X-ray diffraction (XRD) patterns of (a) pure alumina (Al_2O_3) thick film and (b to d) Al_2O_3-polyimide composite thick films by mixing the Al_2O_3 starting powder with the polyimide starting powder at different volume ratios of (b) 4%, (c) 8% and (d) 12%, through ball milling processes, and in comparison to the (e) α-Al_2O_3 starting powder.

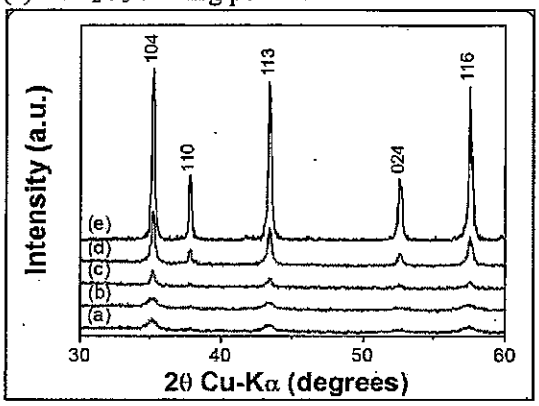

Figure Q3(a)
(Courtesy of H.-J. Kim et al., 2012)

(i) Analyse the XRD patterns in the contexts of *peak observed*, *preferred orientation*, and *crystallinity* of the films, respectively. [9 marks]

(ii) Analyse the crystallite sizes of α-Al_2O_3 of the Al_2O_3-polyimide composite films. Given that the full width at half maximum (FHWM) of the (104) peaks are 0.3216°, 0.2090°, and 0.1608°, for polyimide ratios of 4%, 8%, and 12%, respectively, and the wavelength of the Cu (copper) K_α radiation is 0.1542 nm. [5 marks]

(b) (i) **Figure Q3(b)** shows the Auger spectra of Cr film on gold (Au) seed layer prepared at room temperature (RT) and 300 °C, respectively. Analyse the Auger spectra in the contexts of *elemental composition* and *concentration* of the measured samples.

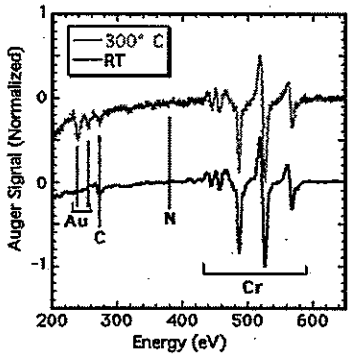

Figure Q3(b)
(Courtesy of T. Kawagoe et al., 2005) [7 marks]

(ii) Discuss how the chemical states or environments of different sample materials, for example, the carbon (C) atoms in graphite and silicon carbide (SiC), can be analysed based on their Auger spectra. [4 marks]

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QUESTION 4

(a) **Figure Q4(a)** shows the Rutherford backscattering spectroscopy (RBS) random (non-aligned) spectrum of a zinc oxide (ZnO) single crystal and the aligned spectra obtained from the RBS channeling mode for the unimplanted ZnO, and the implanted ZnO with different doses or fluences of nitrogen (N) ions.

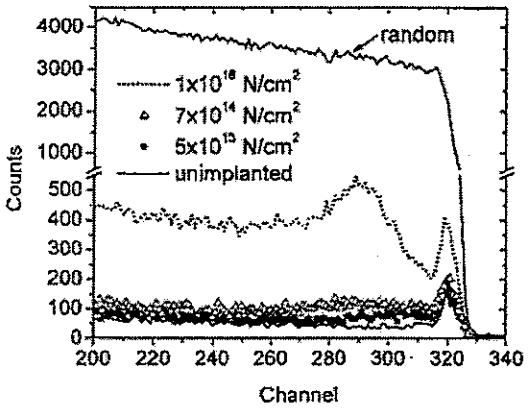

Figure Q4(a)

(Courtesy of K. Lorenz et al., 2005)

(i) Discuss the reason why overall intensities of the aligned spectra are far lower than the random spectrum. [5 marks]

(ii) Analyse the aligned spectra and evaluate the damage that has been incurred in the ZnO crystal for different doses of N ions implantations. [7 marks]

(b) (i) **Figure Q4(b)** shows the Fourier transform infrared (FTIR) spectrum of a biodegradable polymer sample. Analyse the spectrum in the contexts of *peak observed, types of molecular vibrations and bonds*, *functional groups*, and *peak intensity* of the measured polymer.

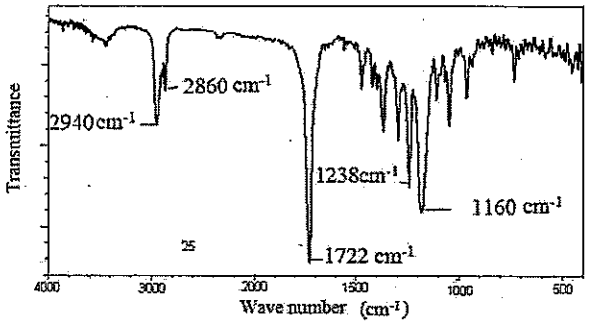

Figure Q4(b)

(Courtesy of B. Abderrahim et al., 2015) [8 marks]

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(ii) With the reference of FTIR spectrum and Raman spectrum given in **Figure Q4(c)**, justify how infrared and Raman spectroscopies provide different but complementary information on the structures and properties of molecules of a measured sample.

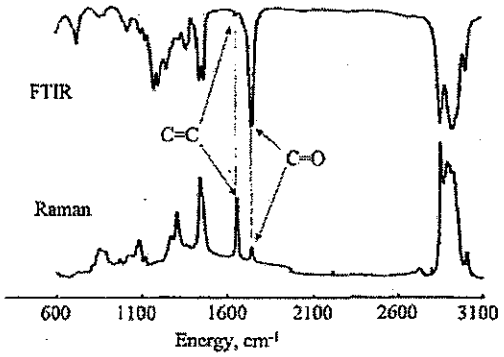

Figure Q4(c)

(Courtesy of R. L. McCreery, 2005) [5 marks]

APPENDIX

Table of Characteristic IR Absorptions

Absorption frequency (cm^{-1})	Functional groups	Compounds
3500–3700	N—H stretching	Amines
3300–3400	O—H stretching	Aliphatic primary amine
3000–3100	C—H stretching	Alkene
2840–3000	C—H stretching	Alkane
1715–1730	C=O stretching	α,β-unsaturated ester
1600–1650	C=C stretching	conjugated alkane
1626–1662	C=C stretching	Alkane
1566–1650	C=C stretching	Cyclic alkene
1500–1550	N—O stretching	Nitro compound
1465	C—H bending	Methylene group
1450–1375	C—H bending	Methyl group
1380–1385	C—H bending	Alkane
1200–1275	C—O stretching	Alkyl aryl Ester
1163–1210	C—O stretching	Ester
1020–1075	C—O stretching	Vinyl Ether
665–730	C=C bending	Alkene

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